Test # 2 (15.7?)

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى
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أجب على جميع الأسئلة	الزمن: ساعتان

Q1.

a.

(i). Briefly describe the phenomenon of magnetization in a magnetic material. What are the different kinds of magnetic materials?

(ii). What is an electric dipole? How is its strength defined? What are the different kinds of electric polarization?

b. An electric field $\vec{E} = 100\rho \sin\omega t \; \vec{a}_\rho$ V/m is given to exist in a certain region, with a relative dielectric constant $\varepsilon_r = 5$ Find the following fields:

(i) – The electric polarization field $\vec{P}$. (ii). The polarization bound charge density ρ_p.

(iii)- The displacement flux density $\vec{D}$. (iv). The volume bound charge density $\vec{J}_p$.

Q2.

a.

(i). Discuss the concept of the conservation of the electric charge.

(ii). Determine the relaxation expression for the time decay of a charge distribution in a conductor if the initial distribution at $t = 0$ is $\rho_{v0} = 6.C/m^3$. If the conductivity of the conductor $\sigma = 3*10^6$ ℧/m and the permittivity $\varepsilon = 18x10^{-12}$ F/m, find the time constant of the free charge density decay. Sketch ρ_v versus time, t

b. Two semi-infinite region, air (region1) for z > 0, and dielectric (region2, in which $\varepsilon = 8\varepsilon_0$) for z < 0, are separated by the interface at z = 0. In the air region, the constant electric field $\vec{E}_1 = -1\vec{a}_x + 1\vec{a}_y + 5\vec{a}_z$ V/m is given.

(i)- Find $\vec{D}$ *and* $\vec{E}$ for both regions.

(ii)- Sketch the $\vec{E}_2$ at the origin.

(iii) Find the refraction angles θ_1 and θ_2 from the normal in both regions if the normal unit vector $\vec{n}$ is directed from region2 to region1.

Q3.

Let us consider two infinite parallel, perfectly conducting planes occupying the planes x = 0 and x = d and kept the potential $\phi(x) = 40$V at x = d, and $\phi(x) = 0$ at x = 0. Solve Laplace's equation in one dimension for the potential function and then find the electric field in the region of interest if the dielectric between the two parallel plane, $\varepsilon = 3\varepsilon_0$.

Q4.

a.

(i)-Explain what is the skin depth (or penetration depth) for a plane wave propagating in lossy medium.

(ii)- Compute the skin depth for sea water with σ =6. S/m, $\varepsilon_r = 80$ and $\mu_r = 1$ (take $\mu_0 = 4\pi \times 10^{-7}$ H/m, $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m) at f = 12GHz.

b. For a plane wave propagating in sea water with $\vec{E}$ field given by,

$\vec{E} = 30e^{\gamma z}\,\vec{a}_x$ V/m.

(i)- what will be the direction of travel? (-Z)

(ii)- Compute α, β, γ and $\hat{\eta}$ for the medium.

(iii)- What will be the expression for $\vec{H}$ field associated with $\vec{E}$ field?

(iv)- What will be the magnitude of the $\vec{E}$ field after traveling 7 skin-depth in the sea water?

Q1b] SPR 2008, Test 2:-

$\bar{E} = 100\rho \sin\omega t \ \bar{a}_\rho$ (V/m) , $\epsilon_r = 5$.

(i) $\bar{P} = ?$ $\quad \epsilon_r = 5 \Rightarrow \chi_e = 5 - 1 = 4$

$$\Rightarrow \boxed{\bar{P} = \epsilon_0 \chi_e E = \epsilon_0 \times 400\rho \sin\omega t \ \bar{a}_\rho}$$

(ii) The polarization charge density ρ_p.

$$\rho_p = -\nabla \cdot \bar{P} = -\frac{\partial}{\rho \partial \rho}(\epsilon_0 * 400\rho \sin\omega t)\rho = \frac{-1}{\rho}[400 * 2\rho \sin\omega t]$$

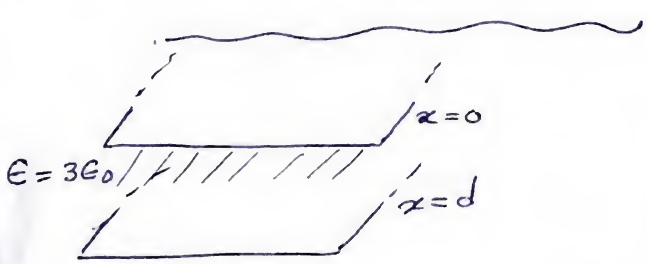
$$\boxed{\rho_p = -\epsilon_0 800 \sin\omega t.}$$

(iii) $\bar{D} = \epsilon_0 \epsilon_r E = 5\epsilon_0 \times 100\rho \sin\omega t \ \bar{a}_\rho$

$$\Rightarrow \boxed{\bar{D} = 500\epsilon_0 \rho \sin(\omega t) \ \bar{a}_\rho}$$

(iv) $\bar{J}_p = \frac{\partial \bar{P}}{\partial t} = \boxed{400\epsilon_0 \rho \omega \cos\omega t \ \bar{a}_\rho}$

Q3]



$\phi = 40\,V\big|_{x=d}$.

$\phi = 0\,V\big|_{x=0}$

Q: Solve the $\nabla^2\phi = 0$ for (1-D).

• for one dimension:- $\frac{\partial^2\phi}{\partial x^2} = 0$

$$\int \frac{\partial^2\phi}{\partial x^2} = \int 0 \Rightarrow \frac{\partial\phi}{\partial x} = C_1$$

$$\int \frac{\partial\phi}{\partial x} = \int C_1 \Rightarrow \boxed{\phi = C_1 x + C_2}$$

$$\phi\big|_{x=0} = 0 = C_1(0) + C_2 \Rightarrow \boxed{C_2 = 0}$$

$$\phi\Big|_{x=d} = 40 = C_1 \times d \Rightarrow \boxed{C_1 = \frac{40}{d}}$$

$$\Rightarrow \boxed{\phi(x) = \frac{40}{d} x}$$

$$\bar{E} = -\nabla\phi = -\frac{\partial}{\partial x}\phi(x) = \frac{-\partial}{\partial x}\left(\frac{40}{d}x\right) = \boxed{\frac{-40}{d} a_x}$$

$$\Rightarrow \bar{D} = \epsilon \bar{E} = 3\epsilon_0 \times \frac{-40}{d} a_x = \boxed{\frac{-120}{d} \bar{a_x}}.$$

Q3 b] Solve Laplace's equation for (1-D) for the potential function $\phi(x)$ subject to the following boundary Conditions:-

$\phi(x) = 100\,V$ at $x=0$, and $\bar{E} = 100\,V/m$.

Sol$^{\underline{n}}$

$\because \nabla^2\phi = 0 \Rightarrow \frac{\partial^2\phi}{\partial x^2} = 0 \Rightarrow \boxed{\phi = C_1 x + C_2}$ $\Rightarrow \phi(x)\Big|_{x=0} = C_1 x + C_2 = C_1(0) + C_2$

$; \phi(0) = 100 \Rightarrow \boxed{C_2 = 100}$

$$\Rightarrow \boxed{\phi(x) = C_1 x + 100}$$

$$\because E = -\nabla\phi = \frac{-\partial}{\partial x}(C_1 x + 100) = -C_1 = 100$$

$$\Rightarrow \boxed{\phi(x) = -100x + 100}$$